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LEAD WOOL*

By R. J. Thomas

In calling attention to lead wool as a material for calking joints in cast iron pipes, the author does not claim to bring up a new subject; but it does seem at this time, when the price of pig lead has risen so enormously while lead wool has not advanced materially, that it is a favorable opportunity to make tests to ascertain whether or not it will pay to use lead wool to the exclusion of cast lead.

The material most used to calk joints in cast iron pipes is cast lead. The yarn or oakum is loosely pounded into the bell around the spigot and then about 2½ inches of cast lead are poured into the joint. The lead shrinks when cooling and there is no contact between the iron pipe and the upper or bell side of the lead, so that it becomes necessary to calk the lead in order to swell it sufficiently to close this space caused by shrinkage. It is manifestly impossible to pound this lead hard enough to make it expand for more than ½ inch, leaving about 2 inches of lead which are absolutely useless in so far as strength of the joint is concerned. It has some strength in holding back the yarn, but for all practical purposes it would be just as well to fill the joint with yarn and then run in ½ inch of lead, only that this would not give enough metal to expand properly and it would be pushed into the spigot rather than expand.

Every superintendent is familiar with the delays of the melting pot; the danger of spilling hot lead, and the waste which comes from handling it. The author has seen a melting pot containing about 200 pounds of metal from which at least 25 pounds of dross had been taken, so that 10 per cent was wasted in this way. He has seen trenches held up because it was too cold to pour the joints or because rain had filled the bells with water. So without intending to disparage the material which has been used for so many generations in water works practice, it is believed that there are so many points in favor of lead wool that it may pay to discuss the subject at this time.

Assume that a bell-and-spigot joint is a stuffing box and the advantage of the yarn is the flexibility which it gives to the line. Now in using lead wool, one of the most essential features is the calking of the yarn into the joint as tight as possible. It has been said that joints which have been calked with a pneumatic hammer and stood a hydraulic pressure of 1800 pounds showed, when the joint was cut to demonstrate its character, the yarn bulged up like rubber, proving that the whole line must have been under tension and that any expansion or contraction could readily have been taken up. It therefore seems obvious that the great advantage coming from the use of lead wool is due to the fact that as the strands of lead wool are pounded into the bell, the compression on the yarn is constantly increased and as good an effect is produced as by using a rubber packing held in place with a clamp.

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* Read at the Richmond Convention, May, 1917.

The impression exists that lead wool joints are too expensive to make and that the first cost is prohibitive. No doubt a lead wool joint cannot compete with a cast lead joint in point of time in making. It can, however, save fully 25 per cent of the lead used, which at the present time is quite an item, but it does require more yarn and certainly requires more labor to make it satisfactorily than a cast lead joint. But consider just what this labor is of which more is required. For instance, a gang of calkers laying 36 inch pipe can lay 10 or 15 lengths a day. With a cast lead joint these 15 joints can be poured in an hour, and with a pneumatic hammer they can be set back ½ inch, with two calkers, in eight hours. This would give joints without the yarn being compressed and with just half an inch of lead holding at the joint. Some of these joints at 150 pounds pressure would leak and the chances are that three out of fifteen joints would be imperfectly run, and would have to be made over.

If the same joints were made with lead wool it is manifestly true that no two calkers can yarn and calk fifteen 36 inch joints in one day satisfactorily. The best two calkers can do would be seven joints in one day of ten hours, and they would be exceptional workers, and five 36 inch joints a day is about the best that two calkers can do. It therefore would seem on first observation that with 36 inch pipe three times the number of calkers will be required to do the work with lead wool as with cast lead. As a matter of fact the lines of pipe where 15 lengths of 36 inch pipe can be placed in position in a day are very unusual and it is very rare indeed for the average calker to do more than four hours of useful work out of a day of eight or ten hours. The rest of the time he is waiting for the lead to melt or the pipes to be put in position or for sundry other causes. It is obvious, therefore, that while theoretically it will take three times as long to make the lead wool joint, practically this is not the case. When it is considered that the lead wool joint will be capable of standing a hydraulic pressure even as high as 3600 pounds to a square inch, that the yarn will be under compression, and that the leakage from breaks will probably be eliminated, there is an advantage in favor of the lead wool joint which cannot be too strongly insisted upon.

The author wishes to quote here from the report of Committee on Cast Iron Pipe Joints (1915) of the American Gas Institute, Mr. Walton Forstall, author:

> The joints were made with 20-inch special bells and tested in a testing machine of 500,000 pounds capacity at the University of Pennsylvania and were subjected to alternate compression and tension. The tests were based on the fact that a 20-inch cast iron main underground subjected to a temperature change of 30° would be stressed 125,000 pounds and would be subjected to alternate compression and tension due to the seasonable changes. In these tests the joints were made up as carefully as possible, the bells being of the standard A. G. I. depth. During the alternate compression and tension stresses placed on the joint, air pressure of from 2½ to 4 pounds was kept on the joint and they were tested for leaks by using a trough made of putty around the joint and filling the trough with water. This was a more positive method of testing than with soap suds.
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> The cement joint, which was made in the usual way and not according to the committee's specification, as this work was undertaken before the final specification was prepared, failed under a tension strength of 40,000 pounds, approximately one-third the safe load. The cast iron joint made with the standard method with yarn and cast lead properly calked failed after six reversals at about 25,000 pounds. Lead wool joints with 1 inch, 1¼ inches and 1¾ inches of lead wool calked with a pneumatic hammer in the usual way remained tight for 50 reversals with a maximum of 80,000 pounds tension and compression with a movement greater than would be experienced by the main underground.
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> The combination cement and lead wool joint consisting of back yarn, a band of cement which was allowed to set and then lead wool calked in front proved to have about the same efficiency as the lead wool and yarn alone.
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> These experiments were continued with cement, cast lead, lead wool, and combination lead wool and cement with the results that the lead wool or combination cement and lead wool, calked with a pneumatic hammer, was shown to be the most satisfactory under laboratory conditions.

It would seem from this report and from the general experience of the gas companies using lead wool, particularly now that the price of lead wool is more nearly approaching that of pig lead, that this is a good opportunity for water works men to decide whether this material shall come into more general use. The author has cited its use on 36 inch mains to show just wherein the great diversity of cost is most apparent. He would next call attention, to the manner in which lead wool has been most successfully employed by the Detroit City Gas Works. Its practice is to calk three lengths of 16-inch pipe together before lowering them into the trench. This reduces the cost of bell holes two-thirds and enables the calkers to work ahead, so that the pipes are ready before the trench is dug. It is said that this was so successfully done in Detroit that more than six weeks of time was saved on one pipe line. On 6-inch pipe, six lengths may be calked together and the pipe rolled into the trench. Generally ropes are employed to lower the pipe, but the pipe may be thrown right into the trench without fear of breaking the joint. It is then caught up with chain-falls and drawn back to fit the bell. It has been said that the calkers working outside of the trench do nearly three times the amount of work without fatigue as in it, that men seek the job and that their health is so vastly improved that the old distaste for calking disappears and the calker seeks the job rather than having to be coerced into doing the work.

The Water Department of Springfield, Mass., laid several years ago a line of 42-inch pipe, using lead wool for the joints. Three hundred joints were made in all. This pipe, although carrying 150 pounds pressure, has proved absolutely tight. The Metropolitan Water Department of Massachusetts has also laid a line of 42-inch pipe, using lead wool exclusively on the joints.

Lead wool has been before the public for more than ten years and the price maintained on it has been due to some patents which are now expiring, so that its high price compared with pig lead will no longer be so conspicuous. It therefore seems to the author that superintendents, engineers and contractors should decide for themselves whether or not the lead wool joint has sufficient merit to warrant putting in the extra time which is required to make it, and, perhaps, at some greater investment on the first cost.

The author would quote from a paper by Mr. Walter Hole, presented at San Francisco, September, 1915.

Reasons of greater strength of lead-wool joints. The greater strength of the lead wool joint is due to two factors. First, the greater compactness of

> the yarn backing of the joint. In making a lead-wool joint the yarn is driven back by each successive ring of lead wool until it becomes quite compact and hard. In the run-lead joint it is more loose and soft. In one case the yarn alone will withstand a pressure of 100 pounds per square inch, while in the other it will not withstand half as much. In the second place, although the run-lead ring may be denser in itself than the lead wool, it does not fill the socket so closely throughout its depth. The run-lead is poured into the socket recess very hot. On cooling, it contracts and shrinks away from the interior surface of the socket. No amount of calking will restore the ring throughout its full depth to gas-tight contact with the two iron surfaces. Under a microscope the effect of calking could be seen to extend to only ⅜ inch from the face of the joint. Compare with this the case of a lead-wool packing, inserted and calked up strand by strand in closest possible contact from back to front and around the whole circumference of the joint, and it is bound to be the more gas-tight and stronger of the two.
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> *Crystallization of lead ring.* Several interesting points in connection with a run-lead joint are brought out in the cut [not reproduced]. The section taken was from one of the joints tested for specific gravity, and pickled in nitric acid to throw up the crystals. The section is exactly 2 inches long and the vertical lines divide the joint into four equal portions. In the portion at the back of the joint and up to the halfway line the crystals are quite normal. Then for ¾ inch there is an area of disturbed crystals due possibly to the presence of vapors and to interrupted crystallization. For ⅜ inch from the face of the joint the effect of calking is more or less clearly marked. The cooling line running horizontally through the center of the lead ring is very noticeable for 1 inch from the back, but becomes much less distinct towards the face, disappearing altogether as the face of the ring is reached. As previously suggested, shrinkage towards the center, which produces such a line, is one of the reasons for the essential inferiority of the run lead ring.

The author will not take up time with considering this material for remaking cast lead joints, or stopping leaks, and many other things for which it is well adapted. In New England a water works superintendent would not feel at ease if he did not have a stock of lead wool for repairing leaky joints and making new joints in especially bad places. But from what he has read and from observation, the author believes lead wool has a broader field of usefulness and that it will bear deep study.